Fe Kα line emission from Molecular Clouds in the Galactic Center: beyond X-ray Reflection Nebulae

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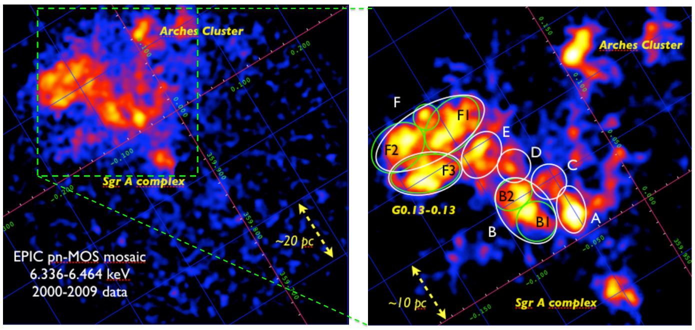
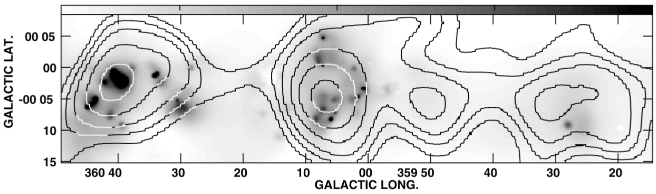
The diffuse structure and variability of the Fe Ka line emission from Molecular Clouds (MCs) in the Galactic Center (GC) region may be an imprint of the recent history of Sgr A*. Two main scenarios have been invoked to explain this diffuse emission are the X-ray Reflection Nebulae (XRN) model, where the energizing photon source is a past transient event (most likely from Sgr A*) reaching a luminosity of 10^{38-39} erg/s, and the Cosmic-Ray (CR) bombardment model. The 6.4 keV line flux has been found to be variable on a 4-5 years timescale in Sgr B2 and some other MCs in the inner Galaxy; this seems to favor the XRN hypothesis. However, the pattern of variability, the spectral features, the correlation of the Fe Ka topology with TeV emission contours and the distribution of High Velocity Compact Clouds suggest that CRs can also be a major contributor to the Fe fluorescent emission.



MCs identification: F=F1+F2+F3 → G0.13-0.13. B2+D+E=*bridge* (Ponti+10)

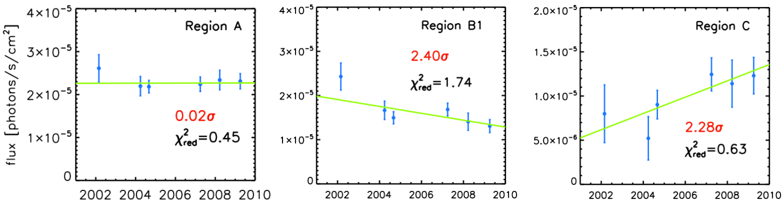
✓ East-West asymmetry of Fe Ka emission.
✓ Remarkable correlation between low surface brightness Fe fluorescence (diffuse blue) and H.E.S.S. TeV emission contours (hadronic interaction of CRs with MCs)

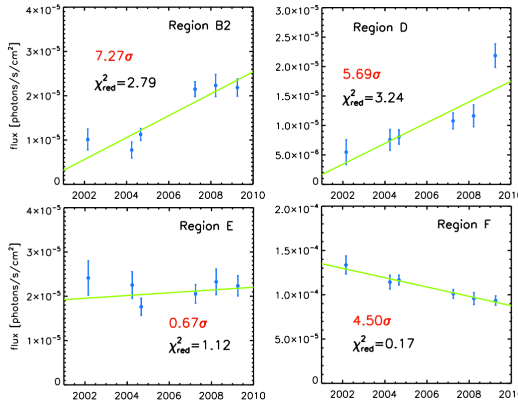


Yusef-Zadeh et al. 2007

This suggests that CRs play an important role in producing Fe fluorescence in GC MCs.

<u>Fe Ka variability study</u>. *Method*: MOS data, background modeling (systematics due to local background subtraction).

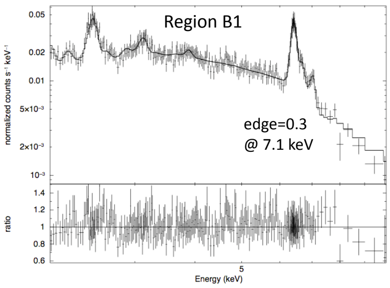




Similar pattern of variability found by Ponti+10

- ✓ Complex pattern of variability. Apparently disconnected from each other.
- ✓ Variability pattern in B2-D-E not clear. Eastward propagation unlikely.
- ✓ Sgr A* is not the only way to account for variability: ***shocks in SNR*** (Uchiyama & Aharonian 2008).
- ✓ In the Sgr A* framework, a multi-flare scenario must be invoked (with CRs)
- ✓ ***Multiwavelength*** study is needed - **radio to TeV**

<u>Looking for the Reflection imprints</u>. *Method*: stacking of the PN data, background subtraction.



In the XRN scenario an absorption edge is needed @ 7.1 keV. About 30% (Fe fluorescence yield) of the absorbed photons are then re-emitted in the form of Fe Ka photons.

Fe K absorption edge only measured in A & B1

	$F^{edge}_{7.1-12}$	$F_{7.1-12}$	30% diff	Fe Ka	ratio
A	5.9±0.4	7.3±0.5	0.4±0.2	1.9±0.1	4.5 (3.0)
B1	4.6±0.4	5.3±0.5	0.2±0.2	1.4±0.1	6.7 (3.3)
T	13.7±0.6	14.3±0.6	0.2±0.2	2.16±0.04	11.0 (4.2)

Fluxes in photons/cm²/s

CRs entering the clouds are slowed down and emit non-thermal bremsstrahlung radiation; photons with energies > 7.1 keV can induce inner shell ionization from a Fe atom together with the ionization produced directly by particles collisions.

Reflection may dominate in some MCs, but CRs bombardment may be the major contributor in others.

Future developments: ***IXO*** will unambiguously identify the energising source, measuring the line width broadening (typical feature of the CRs bombardment scenario) and/or the geometry dependent polarization of the underlying continuum; this is expected in XRN, since Thomson scattering polarizes the incident photon flux.

References: Capelli R. et al. A&A submitted; Ponti G. et al. 2010, ApJ, 714, 732; Yusef-Zadeh F. et al. 2007, ApJ, 656, 847 (& references therein)